1.5 Search for X-ray-Induced Acceleration of the Decay of the 31-Yr Isomer of ^{178}Hf

Releasing the energy stored in an isomeric nuclear state in a controlled way with an atomic or electromagnetic trigger is an attractive speculation: the energy gain is on the order of the ratio of nuclear/atomic energies (i.e., MeV/keV). (Nuclear isomers are loosely defined as excited nuclear states with lifetimes longer than 10^{-9} s.) Nuclear isomers, therefore, represent an opportunity for a stand-alone energy source if suitable schemes for trigger and control of the energy release can be found. Potential applications include space drive, as well as very bright gamma-ray sources. The nucleus ^{178}Hf has a nuclear isomer with excitation energy of 2.447 Me. The 2.447 MeV isomeric state decays slowly (31 year half life) to the nearby state at 2.433 MeV. This $J = 13^-$ state then loses energy in a rapid ($\sim 10^{-12}$ s) gamma-ray cascade ending at the 8^- rotational band head, which in turn decays via the ground-state rotational band cascade. The gamma-ray cascade is delayed at the 8^- state at 1.147 MeV, since the 8^- state is also isomeric, with a half-life of 4 s.

Reports of triggered decay of the ^{178}Hf isomer induced by x-rays delivered by a dental x-ray machine have been made (Collins et al., 1999). Enhancements amounting to 1-2% in the isomer decay rate had been reported for various gamma rays in the cascade. The reported integrated cross section for triggering the decay is 10^{-21} cm^2 keV, so large as to demand new physics. A collaboration involving LANL, LLNL, and ANL have sought to verify these reports taking advantage of the intense photon flux available at the APS beamline 1-ID, using white beam from a tapered undulator source. No induced decay was observed. The upper limits for the energy-integrated cross section for such a process, over the range of x-ray energies 20-60 keV, are less than 2×10^{27} cm^2 keV, below the previously reported values by more than 5 orders of magnitude.

1.6 X-ray Microscopy and Microtomography

Since the last *Experimental Facilities Division/User Program Division Technical Progress Report* (ANL/APS/TB-38, 2000), the Micro-Techniques Group (now called the X-ray Microscopy Group) has continued to focus its efforts in the x-ray microscopy field. Application emphases were mainly in the biological/biomedical, environ-mental, and materials areas.

Novel x-ray microscopy experiments in the biomedical and environmental sciences continued to thrive. This was facilitated by operating two hard x-ray microprobes in parallel, with microfluorescence taking up ~40% operation of the 2-ID-D microprobe, and ~80% of the 2-ID-E side-branch microprobe. The high elemental sensitivity and spatial resolution of these instruments enabled trace elemental analyses in tissues, eukaryotic cells, and microorganisms at naturally occurring concentrations or at clinically relevant doses. Applications included studies of Pt- and Cu-derivative drug metabolism and Cr-induced carcinogenesis, metal contaminants in microbes at mineral surfaces and in marine and freshwater environments, metal distribution during cellular processes, and transfection of nanocomposites in cells. To explore these and future applications, we held a workshop on 14-15 May 2001, titled "Biological Applications of X-Ray Microbeams" (Lai et al., 2002). About 50 current and potential users attended. Other imaging modalities also flourished,